CRACKER BURST

INJURIES OF HAND

Dissertation submitted to

THE TAMIL NADU Dr.M.G.R.MEDICAL UNIVERSITY

In partial fulfillment of the regulations for the award of the degree of

M.Ch BRANCH- III

PLASTIC SURGERY

INSTITUTE FOR RESEARCH AND REHABILITATION

OF HAND & DEPARTMENT OF PLASTIC SURGERY

STANLEY MEDICAL COLLEGE AND HOSPITAL

CHENNAI-1, TAMIL NADU, INDIA

CERTIFICATE

This is to certify that the dissertation titled **CRACKER BURST INJURIES OF HAND** of **Dr.S.SENTHIL KUMARAN** is submitted in partial fulfillment of the requirements for **M.Ch. Branch-III (Plastic surgery)** examination of the **TamilNadu Dr.M.G.R.Medical University** to be held in august 2007. The period of study was from January 2005 to January 2007

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DECLARATION

I, **Dr.S.SENTHIL KUMARAN**, solemnly declare that the dissertation titled **CRACKER BURST INJURIES OF HAND** is a bonafide work done by me at INSTITUTE FOR RESEARCH AND REHABILITATION OF HAND, STANLEY MEDICAL COLLEGE AND HOSPITAL during January 2005 to January 2007, under the guidance and supervision of my Head of Department **Prof.T.C.CHANDRAN**.M.S., M.Ch (Plastic Surgery) The dissertation is submitted to Tamil Nadu Dr.M.G.R.Medical University,towards partial fulfillment for the award of **M.Ch.Degree** (Branch-III) in **Plastic Surgery**

Place: **Dr.S.SENTHIL KUMARAN**

Date:

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INDEX

AIM

To analyze and classify the pattern of Cracker burst injuries of Hand, treatment options available and outcomes

MATERIALS AND METHODS

70 consecutive patients presented to the emergency hand injury service of our department with the history of accidental cracker burst injury to their hand or hands from January 2005 to January 2007 were taken for analysis.

A **proforma** was prepared and detailed history was obtained, thorough general examination were performed before the assessment of the hand wounds, then appropriate investigations were performed, patients were reviewed after the investigations and appropriate treatments were offered primarily.

RELATED ANATOMY OF HAND

As the thumb is the most affected part in the hand following the cracker burst injuries, few relevant anatomies about it is mentioned below

Thumb web muscles

ADDUCTOR POLLICIS

Origin

OBLIQUE HEAD: palmar surfaces of the Trapezoid, the Trapezium and Capitate as well as the bases of the Index and Middle metacarpals

TRANSVERSE HEAD: palmar surface of the shaft of the Middle metacarpal

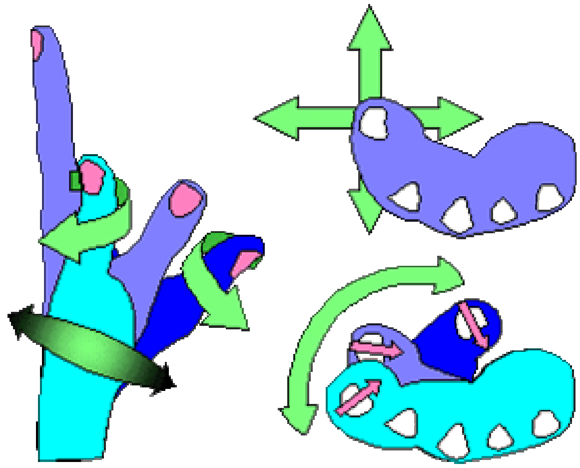
Insertion: The palmar ulnar base of the Thumb Proximal Phalanx, the Thumb Ulnar MCP Sesamoid, and the Thumb extensor mechanism

Function: radially adducts the thumb basal joint along with other muscles which radially adduct the basal joint, and extends the thumb interphalangeal Joint

Nerve: Motor Branch of Ulnar Nerve

Artery: Deep Palmar Arch

THUMB MOVEMENTS



Bones:

- Trapezium
- Thumb Metacarpal

Ligaments:

Range of motion

Palmar Adduction/Abduction Contact/45,

Radial Adduction/Abduction Contact/60

Movement

- palmar abduction
- radial abduction
- palmar adduction
- radial adduction

- opposition
- retropulsion

MECHANISM OF CRACKER BLAST

Anatomy of cracker

Firecracker

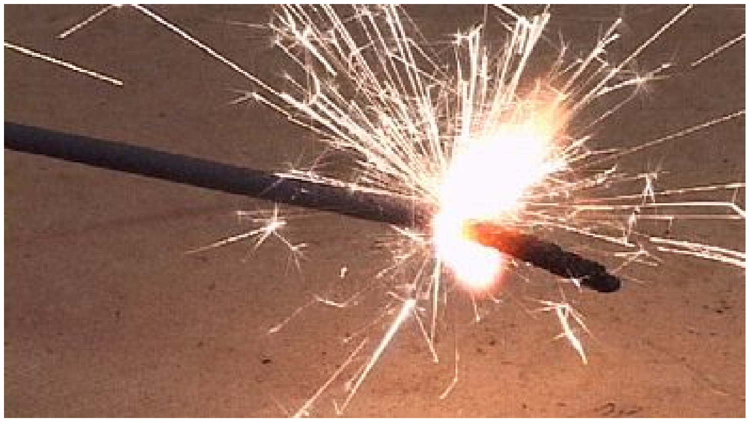
A **firecracker** (also known as a **cracker**, **noisemaker**, or **banger**) is a small explosive device primarily designed to produce a large amount of noise, especially in the form of a loud bang; any visual effect is incidental to this goal.

Firecrackers, along with Fireworks are now thought to have originated in China.

Firecrackers have been around for hundreds of years. They consist of either **black powder** (also known as gunpowder) or **flash powder** in a tight paper tube with a fuse to light the powder. Black powder contains charcoal, sulfur and potassium nitrate. A composition used in a firecracker might have aluminum instead of or in addition to charcoal in order to brighten the explosion.

Sparklers are very different from firecrackers. A sparkler burns over a long period of time (up to a minute) and produces extremely bright and showery light. Sparklers are often referred to as "snowball sparklers" because of the ball of sparks that surrounds the burning portion of the sparkler. a sparkler consists of several different compounds:

- **A fuel**
- **An oxidizer**
- **Iron or steel powder**
- **A binder**



Oxidizers -- potassium nitrate is a very common one. The **fuel** is charcoal and sulfur, as in black powder. The **binder** can be sugar or starch. Mixed with water, these chemicals form a slurry that can be coated on a wire (by dipping) or poured into a tube. Once it dries, you have a sparkler. When you light it, the sparkler burns from one end to the other (like a cigarette). The fuel and oxidizer are proportioned, along with the other chemicals, so that the sparkler burns slowly rather than exploding like a firecracker.

It is very common for fireworks to contain aluminum, iron, steel, and zinc or magnesium dust in order to create bright, shimmering sparks. The metal flakes heat up until they are incandescent and shine brightly or, at a high enough temperature, actually burn. A variety of chemicals can be added to create colors.

Aerial Fireworks

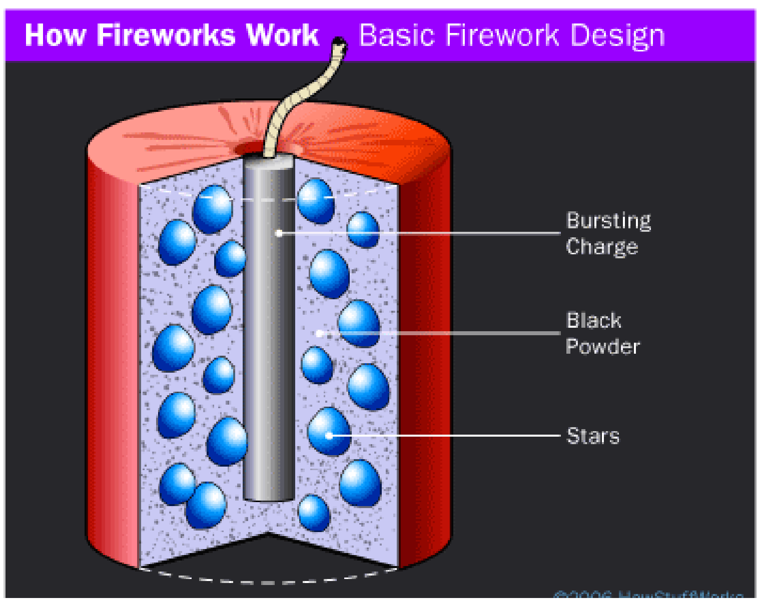
An aerial firework is normally formed as a **shell th**at consists of four parts:

- **Container -** Usually pasted paper and string formed into a cylinder
- **Stars -** Spheres, cubes or cylinders of a sparkler-like composition
- **Bursting charge -** Firecracker-like charge at the center of the shell
- **Fuse -** Provides a time delay so the shell explodes at the right altitude

Located just below the shell is a small cylinder that contains the lifting charge.

These are small shells, about the size of a peach .The sphere is the shell, and the small cylinder below is the lifting charge that shoots it out of the launch tube. The green fuse lights the lifting charge, which in turn lights the shell's fuse. Shells that you see at a show are typically the size of a cantaloupe or even larger**.**

The shell is launched from a mortar. The mortar might be a short, steel pipe with a lifting charge of black powder that explodes in the pipe to launch the shell. When the lifting charge fires to launch the shell, it lights the shell's fuse. The shell's fuse burns while the shell rises to its correct altitude, and then ignites the bursting charge so it explodes.



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Simple shells consist of a paper tube filled with stars and black powder. Stars come in all shapes and sizes, but you can imagine a simple star as something like sparkler compound formed into a ball the size of a pea or a dime. The stars are poured into the tube and then surrounded by black powder. When the fuse burns into the shell, it ignites the bursting charge, causing the shell to explode. The explosion ignites the outside of the stars, which begin to burn with bright showers of sparks. Since the explosion throws the stars in all directions, you get the huge sphere of sparkling light that is so familiar at fireworks displays.

Types of Explosions

Conventional fire cracker

The explosion of a conventional fire cracker generates a blast wave that spreads out from a point source. The blast wave consists of two parts — a shock wave of high pressure, followed closely by a blast wind, or air in motion. The physics of blast waves is nonlinear and complex. In general, damage produced by blast waves decreases exponentially with distance from the point source of the blast. This factor is very important in hand injuries, because injury occurs mostly when the victim is holding the cracker in his/ her hand.

When explosions occur indoors, standing waves and enhanced differences in pressure occur because of the additive effects of reflections or reverberations from walls and rigid objects. As outward energy dissipates, a reversal of wind back toward the blast and under pressurization occurs. The resulting pressure effect damages organs, particularly at air–fluid interfaces, and the wind propels fragments and people, causing penetrating or blunt injuries.

Enhanced-Blast Explosive Devices

Enhanced-blast explosive devices, in contrast, can have more damaging effects. A primary blast from these devices disseminates the explosive and then triggers it to cause a secondary explosion. The high-pressure wave then radiates from a much larger area, prolonging the duration of the over pressurization phase, thus increasing the total energy transmitted by the explosion. Enhanced-blast devices cause a greater proportion of primary blast injuries than do conventional devices.

Types of Blast Injuries

The effects of blasts fall into the following **four categories:**

Primary (direct effects of pressure),

Secondary (effects of projectiles),

Tertiary (effects due to wind), and

Quaternary (burns, asphyxia, and exposure to toxic inhalants)

The types of injuries caused by blasts depend on whether the blasts occur outdoors in open air or within buildings and whether they cause the collapse of a building or other structure.

MECHANISMS OF INJURIES

The four basic mechanisms of blast injury are termed as primary, secondary, tertiary, and quaternary). An example that causes primary injury is **blast wave**, which refers to the intense over-pressurization impulse created by a detonated firecracker or bomb. Blast injuries are characterized by anatomic and physiologic changes that occur when the direct or reflective over-pressurization force impacts the body's surface. The blast wave (over-pressure component) should be distinguished from **blast wind** (forced superheated air flow).

TABLE 1

MECHANISMS OF BLAST INJURY

Category	Characteristics	Body part	Affected types of injuries
Primary	Unique to high-order explosives; results from the impact of the	Gas-filled structures are most	
			HAND INJURIES Blast lung

	overpressurization wave with body surfaces	susceptible: lungs, GI tract, middle ear	Tympanic membrane rupture and middle-ear damage Abdominal hemorrhage and perforation Globe (eye) rupture Concussion (traumatic brain injury without physical signs of head injury)
Secondary	Results from flying debris and bomb fragments	Any body part	Penetrating ballistic (fragmentation) or blunt injuries Eye penetration (can be occult)
Tertiary	Results when bodies are thrown by blast wind	Any body part	Fracture and traumatic amputation Closed and open brain injury

			Burns (flash, partial- and full-thickness) Crush injuries
Quaternary	All explosion-related injuries, illnesses, or diseases not due to primary, secondary, or tertiary mechanisms; includes exacerbation or complications of existing conditions	Any body part	Closed and open brain injury Asthma, COPD, or other breathing problems from dust, smoke, or toxic fumes Angina Hyperglycemia, hypertension

Low-order explosives are classified differently because they lack the defining over-pressurization wave of HEs. Low-order explosives cause injury from ballistics (fragmentation), blast wind (not blast wave), and thermal. There is some overlap between LE descriptive mechanisms and HE's secondary, tertiary, and quaternary mechanisms.

Extremity injury Traumatic amputation, fractures, crush injuries, compartment syndrome, burns, cuts, lacerations, acute arterial occlusion, air embolism–induced injury

Up to 10% of all blast survivors have significant eye injuries, generally due to perforations from high-velocity projectiles.. Findings can include decreased visual acuity, hyphema, globe perforation, subconjunctival hemorrhage, foreign body, or lid lacerations. Liberal referral for ophthalmologic screening is encouraged.

A patient with cracker burst injury to right hand and associated injury to face and chest

Primary Blast Injuries

Primary blast injuries are caused by barotrauma — either overpressurization or underpressurization relative to atmospheric pressure. Primary blast injuries most commonly involve air-filled organs and air–fluid interfaces. Organs are damaged by dynamic pressure changes at tissue-density (e.g., air–fluid) interfaces due to the interaction of a high-frequency stress wave and a lower-frequency shear wave.

One or the other of these waves predominates, depending on the characteristics and location of the blast. Rupture of the tympanic membranes, pulmonary damage and air embolization, and rupture of hollow viscera are the most important primary forms of blast injury.

The lung is the organ that is second most susceptible to primary blast injury. Pressure differentials across the alveolar–capillary interface cause disruption, hemorrhage, pulmonary contusion (appearing as a bihilar "butterfly" pattern on chest radiographs), pneumothorax, hemothorax, pneumomediastinum, and subcutaneous emphysema. Pulmonary injuries are life-threatening; for example, the immediate onset of pulmonary edema with frothing at the mouth (associated with bilateral radiographic "whiteout") carries a grave prognosis.

The colon is the visceral structure most frequently affected by a primary blast injury. Rupture of the colon and, less frequently, the small intestine may occur as an immediate result of a blast. Mesenteric ischemia or infarct can cause delayed rupture of the large or the small intestine; these injuries are difficult to detect initially. Rupture, infarction, ischemia, and hemorrhage of solid organs such as the liver, spleen, and kidney are generally associated with very high blast forces or proximity of the patient to the blast center.

Primary blast injuries to the brain include concussion as well as barotrauma caused by acute gas embolism. Damage to the central nervous system after an explosion has been increasingly attributed to the direct effects of the blast. Serious late effects of traumatic brain injuries, such as central nervous system residua, have brought attention to the need for rehabilitation of the central nervous system after blast exposure.

Secondary Blast Injuries

Many explosive devices contain metallic and other fragments. These and the disintegrated casing are designed to cause penetrating wounds.

Tertiary Blast Injuries

Blasts cause structural collapse and fragmentation of buildings and vehicles. The types and severity of injuries depend on whether they were caused by collapse or fragmentation. The collapse of buildings and other structures causes a higher rate of death (due to crush injuries and entrapment) than does fragmentation. The crush syndrome in victims of structural collapse is a metabolic derangement resulting from damage to muscle tissues and the subsequent release of myoglobin, urates, potassium, and phosphates. Appropriate treatment includes hydration and alkalization.

The compartment syndrome results from the compression that a damaged, edematous muscle exerts within its inelastic sheath. Such confined swelling promotes local ischemia, which then continues a vicious cycle of swelling, increased compartment pressures, decreased tissue perfusion, and further ischemia. Left untreated, compartment syndrome causes local tissue death and also presages development of the crush syndrome. The compartment syndrome usually involves the extremities, and fractures of the long bones commonly give rise to the syndrome. Occasionally, the compartment syndrome may involve the buttocks and the abdominal musculature such as the rectus muscle

Pelvic fractures also may induce intraabdominal hypertension, which requires laparotomy and decompression as lifesaving measures In these cases, urgent application of external fixators should be used to stabilize the pelvis to reduce blood loss.

The characteristic sign of the compartment syndrome is pain out of proportion to the injury. Passive movement of an affected extremity exacerbates pain when the affected compartment of the swollen muscle is placed under tension. Fasciotomy or compartment decompression should be performed as soon as possible. In the unconscious or obtunded patient, monitoring of compartment pressure is useful to determine the need for fasciotomy. A perfusion pressure of less than 35 mm Hg is a reasonable threshold when used in conjunction with clinical assessment.

Quaternary Blast Injuries

Quaternary blast injuries refer to explosion-related injuries, illnesses, and diseases not due to primary, secondary, or tertiary injuries. Quaternary blast injuries encompass exacerbations or complications of persisting conditions.

GRADING OF CRACKER BLAST INJURIES

We have tried to analyze the pattern of injuries , were able to group them in four grade according to the severity. As the severity increases the depth of injury also increases. Amputations are a norm in severe injuries. Below we have provided our grading system for cracker burst injuries.

- **Grade 1**

  Skin and subcutaneous injuries alone

- **Grade 2**

  Thumb web muscle injury, thenar and hypothenar muscle injury, Phalangeal fractures.

- **Grade 3**

  Finger amputations, CMC joint dislocations, metacarpal fractures, distal thumb amputations, nerve and tendon injury.

- **Grade 4**

  Total thumb amputation through CMC joint , finger amputation proximal to MP joint, carpal or fore arm bone fractures and proximal level amputations.

Grade 1

Skin and subcutaneous tissue injuries alone


Grade 2

Thumb web muscle injury, thenar & hypothenar muscle injury, Phalangeal fractures.


Grade 3

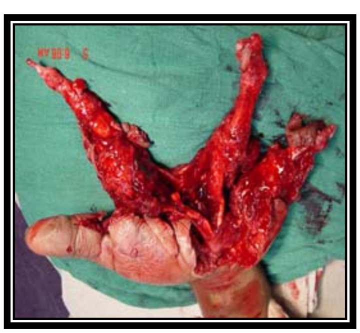
Finger amputations, CMC joint dislocation, metacarpal fractures, distal thumb amputations, nerve & tendon injury.



Grade 3

Grade 4

Total thumb amputation through CMC joint, finger amputation proximal to MP joint, carpal ,forearm bone fractures and proximal level amputations



MATERIALS AND METHODS

Total number of patients; 70

Age group; from 3 years to 80 years

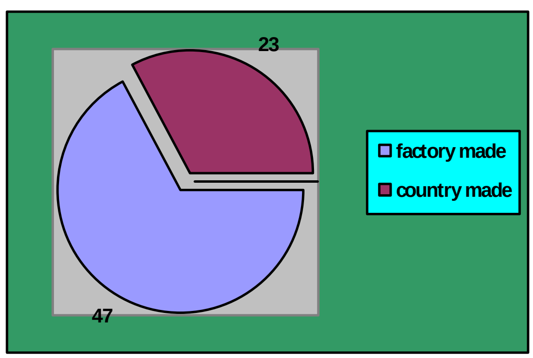
Mean age; 23 years

Children (less than 13 years); 14

Male: female ratio; 64:6

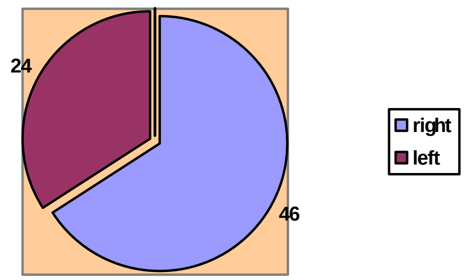
Type of fire cracker used; factory made-47

Country made-23



Hand affected; right -46

Left-24

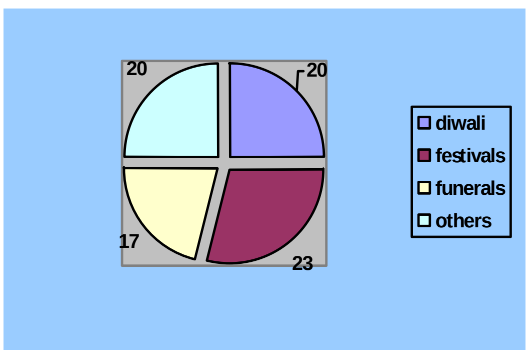


Occasion of injury; diwali-20

Temple festivels-23

Funerals-17

Others-10



Finger most commonly injured;

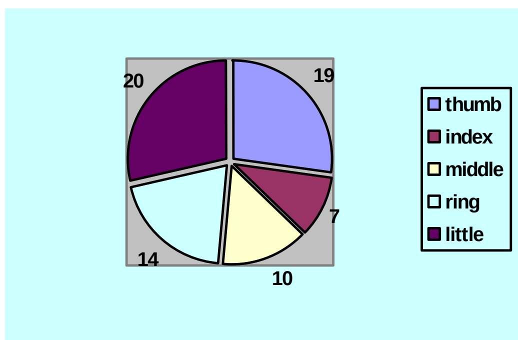
Thumb -19

Little -20

Ring-14

Middle-10

Index-7



Alcohol intoxication at the time of injury; 12 patients (12/70)

Time interval between injury and arrival in the department; from 2 hours to 72 hours

5 patients had taken treatment elsewhere, skin suturing done in 3 patients and shortening closure in 2 patients.

All others where referred to us after first aid bandaging and resuscitation

7 patients required blood transfusion during the resuscitation

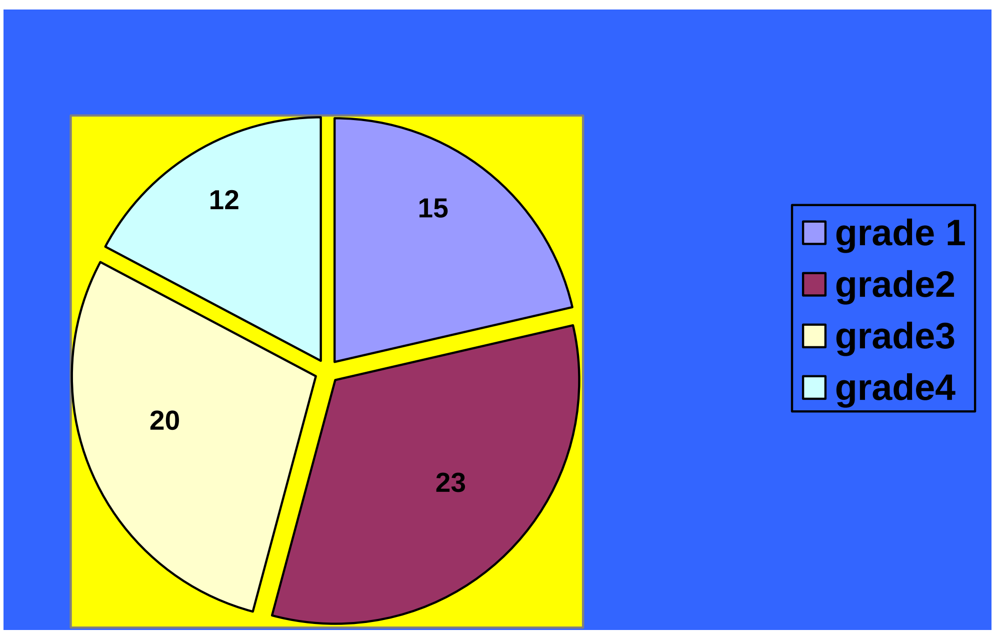
Grading

Grade 1; 15

Grade 2; 23

Grade 3; 20

Grade 4; 12



Serial number	Patient Name	Hand Injured	Age	Sex	Grade	Plastic Surgery Number
1	VIJAY	R	8	M	2	e/7682/h/07
2	RAVINDRAN	R	27	M	2	244978/05
3	GANESAN	L	30	M	1	245664/05
4	BALAJI	R	14	M	3	246015/05
5	GANESH	L	40	M	2	246804/05
6	LAXMANAN	R	40	M	3	247571/05
7	GOPI	R	12	M	4	247999/05
8	VIJAYABABU	R	25	M	2	247568/05
9	NARAYANAN	R	19	M	1	e/7501/h/06
10	BALAKRISHANAN	R	40	M	3	242518/05
11	ARUMUGAM	R	60	M	2	242806/05
12	SHANKAR	L	32	M	1	243544/05
13	NARASIMMAN	L	36	M	3	243633/05
14	VINODKUMAR	R	4	M	2	e/6500/h/06
15	SATHIESH	R	14	M	2	e/6757/h/06
16	SRINIVASAN	R	38	M	2	250178/05
17	PITCHAIKARAN	L	45	M	1	250558/05
18	RAJINI	R	25	M	4	250579/05
19	DASTHAGIR	L	13	M	2	250552/05

20	RAGHU	R	13	M	3	244547/05
21	RAMESH	L	20	M	3	250830/05
22	VERAMUTHU	R	22	M	2	250181/05
23	STALIN	L	30	M	4	e/8678/h/06
24	PARTHIBAN	R	13	M	3	e/68/h/06
25	THANGARAJ	R	50	M	3	e/8086/h/06
26	MURUGAN	R	25	M	1	e/5715/h/06
27	DILLIBABU	R	11	M	2	e/7457/h/06
28	PALANI	R	40	M	3	e/7441/h/06
29	GOPINATH	L	28	M	4	e/7439/h/06
30	SANTHOSHKUMAR	L	15	M	3	e/7440/h/06
31	RAGHU	L	20	M	2	251198/05
32	DHANABAL	R	80	M	3	251355/05
33	ELUMALAI	L	35	M	3	e/5773/h/06
34	KUMAR	L	33	M	2	e/5717/h/06
35	KUMAR.P	L	20	M	4	e/6022/h/06
36	VARADHAN	R	53	M	1	243833/05
37	SABARINATHAN	R	22	M	2	243887/05
38	MEHANDHAR	R	14	M	3	244227/05
39	RAMALINGAM	R	35	M	4	244200/05
40	NAGARAJ	R	14	M	1	244503/05

41	MURUGAN	L	40	M	3	249072/05
42	NARASIMMA	L	23	M	4	249075/05
43	VENKATESH	L	30	M	2	249353/05
44	PANDIAN	R	21	M	4	250753/05
45	JAGADESAN	L	23	M	3	241878/05
46	GOPI	L	17	M	2	242754/05
47	PREMKUMAR	R	23	M	2	252113/06
48	RAJESH	R	10	M	4	251637/05
49	SINDHU	L	4	F	4	251652/05
50	VINODKUMAR	R	22	M	4	252112/05
51	SUBRAMANI	R	11	M	3	250611/05
52	NAVEEN	L	18	M	2	250595/05
53	MANIKANDAN	R	13	M	4	250584/05
54	RAJMOHAN	R	43	M	2	e/7104/h/06
55	SANTHOSH	L	23	M	2	e/7275/h/06
56	PALANISAMI	R	26	M	1	250039/05
57	SIVARAJ	R	14	M	3	242337/05
58	VINITHA	R	10	F	4	250045/05
59	SANGEETHA	R	3	F	1	250010/05
60	DAS	R	31	M	2	250110/05
61	MAHALINGAM	L	35	M	3	251208/05

62	JANARTHANAN	R	50	M	1	248673/05
63	ARUN	R	15	M	3	250175/05
64	SASIKUMAR	L	23	M	4	242212/05
65	MUNUSAMY	R	25	M	1	250021/05
66	CHANDRAN	R	4	M	2	247596/05
67	MEGALA	R	9	F	1	250034/05
68	SIVAGURU	R	7	M	2	250029/05
69	MURUGESAN	R	12	M	1	250018/05
70	KANNAN	R	22	M	3	e/6206/h06

RESULTS

Grade 1 injuries

In our series, out of the 15 patients of grade 1 injuries 9 patients were treated with primary skin suturing, 3 required SSG and another 3 required CFF from the adjacent finger.

Cross finger flaps were divided after 14 days, on the average required 6 to8 dressing changes before complete wound healing, they were able to return to work at an average of 5 weeks.

Follow up of these patients showed complete recovery of function and no deformities.

Grade 2 injuries

Thumb web and thenar muscle injury-7

Hypothenar muscle injury-3

Phalangeal fractures- 20

PPX-3

MPX-8

TPX-9

Average number of secondary procedures-<1

Functional recovery-Good-12

-Adequate -5

-Poor-6

Grade 3 injuries

Thumb CMC joint dislocations-9

‘k’ wire fixation-7

Capsulorraphy-2

Finger amputations-29

Index-11

Middle finger-8

Ring finger-7

Little finger-3

Nerve injuries-9

Thumb digital nerve-8

Others-1

End to side neurorraphy-5

FPL avulsions-9

FDP & FDS injury-2

Primary repair-2

Tendon transfers-4

Palmaris longus to FPL- 3

Opponensplasty-1

Average number of secondary procedures- 2

Functional recovery- good-4

-Adequate- 11

- Poor- 6

Patient satisfaction- satisfied-6

-Unsatisfied-14

Grade 4 injuries

Total thumb amputations- 6

Proximal ampuatations-4

Carpal and forearm bone fractures-3

Skin cover- groin flap-9

- SSG- 3

Pollicization- 1

Average number of secondary procedures- 3

Functional recovery- Good -1

-Adequate-3

- Poor-8

Patient satisfaction- satisfied-1

- Unsatisfied-11

Return to original work- nil.

DISSCUSSION

Treatment Strategies

General Considerations and Immediate Treatment

Initial stabilization of victims of blast injury, like that of other trauma victims, includes assessment and management of the airway, breathing, and circulation. Recommended circulatory support includes the infusion of fluid to maintain a systolic blood pressure of 100 mm Hg, a palpable radial pulse of less than 120 beats per minute and normal mentation. Fluids should not be "pushed" before surgical intervention — clinical and experimental evidence suggests that rapid infusion may increase bleeding.

Management of Specific Injuries

After evaluation for basic life support and after immediate treatment of life-threatening penetrating or blunt injuries, examination of the tympanic membrane can be used to identify persons who may be at risk for late primary blast injuries, particularly in a setting of mass casualties. Rupture of the tympanic membranes suggests possible pulmonary injury. A period of observation with sequential measurement of oxygen saturation is useful for victims who show signs of no other injuries and might help predict delayed pulmonary or visceral injuries for those patients who have begun treatment.

Second, these victims should be monitored by sequentially measuring their oxygen saturation by pulse oximetry. Decreased oxygen saturation probably signals early "blast lung" (pulmonary barotrauma) even before symptoms begin. Treatment of blast lung is challenging in that ventilation with high peak inspiratory pressures increases the risk of air embolism or pneumothorax. Ventilation should use limited peak inspiratory pressures and permissive hypercapnia; when available, high-frequency ventilation may be of value.

Fluid levels must be managed to avoid overload, because damaged lung tissue is particularly susceptible to the development of edema; definitive roles for corticosteroids and antibiotics have yet to be delineated. The patient should be continuously monitored for developing pneumothorax and treated promptly with tube thoracostomy should this ensue.

Impalement injuries, penetrating wounds, burns, and long-bone fractures can also be produced by blasts. Objects that are impaling a person should be removed or manipulated only in an operating room. To facilitate the transport of impaled patients, the objects can be cut or shortened.

Before a patient is transported to a burn unit, burns should be covered to prevent heat loss and to minimize fluid loss due to disruption in dermal integrity. Also, fluid resuscitation with an appropriate burn formula should be started. The larger the burn, the more heat and fluid are lost. Covering the burn area, ideally with a sterile material, prevents further contamination.

Transporting patients with long-bone fractures requires temporary splinting to manage pain and also to avert further soft-tissue damage. Effective splinting minimizes further neurovascular compromise and bleeding. Obvious gross deformities may be gently realigned before splinting. Open fractures must be immobilized and covered with bulky sterile dressings, and therapy with systemic broad-spectrum antibiotics should be begun. Tetanus prophylaxis or booster injections should be given during initial treatment.

Up to 28 percent of blast survivors may have serious eye injuries, particularly if the blast caused shattering glass. These injuries include corneoscleral lacerations, orbital fractures, hyphema, lid lacerations, traumatic cataracts, injury of the optic nerve, serous retinitis, and rupture of the globe itself. Chemical burns of the eye should be treated by at least 60 minutes of continuous irrigation with sterile saline.

Hand injured patients are refered to us after stabilisation of the general condition. The wounds are assessed and necessary investigations and consent are obtained .

Treatment of grade 1 injuries

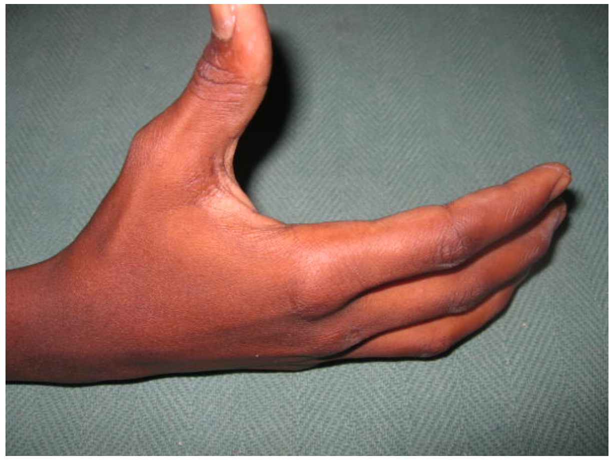
These injuries need debridement and skin replacement

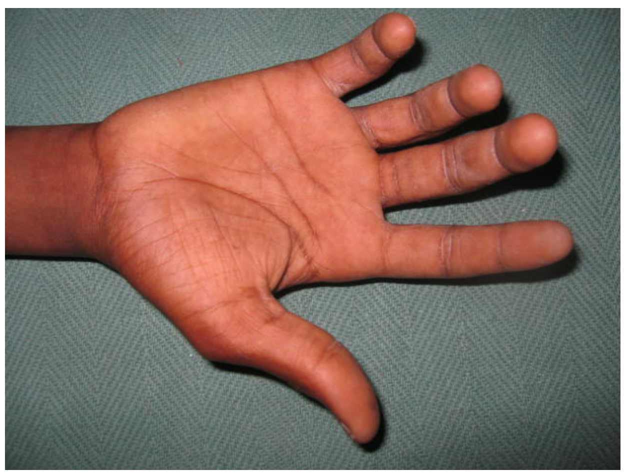
Most of the wounds are amenable to Primary skin suturing, rest of the wounds were treated with split skin grafts or a cross finger flaps.

In our series, out of the 15 patients of grade 1 injuries 9 patients were treated with primary skin suturing, 3 required SSG and another 3 required CFF from the adjacent finger.

Cross finger flaps were divided after 14 days, on the average required 6 to8 dressing changes before complete wound healing, they were able to return to work at an average of 5 weeks.

Follow up of these patients showed complete recovery of function and no deformities.





Treatment of grade 2 injuries;

When web skin alone is injured primary skin suturing is sufficient, but when thumb web muscles like adductor pollicis or first dorsal interrosseous muscle were injured they were likely to be crushed and nonviable at the cut ends. These crushed muscles were debrided fully and may not be amenable for repair. The skin closure done in the usual way, this loss of muscle mass results in post operative stiffness of thumb movements due to scar tissue formation in the subcutaneous plane of thumb web, but in long term follow up doesn’t produce any functional deficiency.

Hypothenar muscle injury;

Hypothenar muscle needs to debrided as the thenar muscles and skin cover done as required. Post operatively this doesn’t give rise to any functional problems in an otherwise normal hand.

Phalangeal fracture

Proximal phalanx fractures mostly were compound and they required stabilization, our practice is to fix them with oblique ‘K’ wire or criss cross ‘k’ wires. But when the fingers were partially amputated and distal part vascularity is precarious we usually mould the fracture and apply a dorsal POP slab. These injuries produce stiffness of the PIP joint in the post operative period.

Middle phalanx fractures were treated with longitudinal ‘K’ wire passed across the DIP joint stopping short of PIP joint.

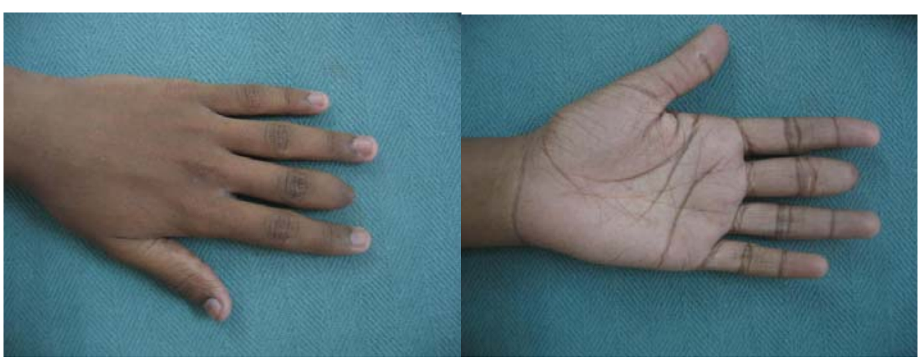
Treatment of Grade 3 injuries

These injuries result in severe unrepairable damage to the soft tissues, and skeletal structure

Finger amputations

The fingers amputations occur through the weakest points like through the joints. The distal amputated parts are torn into pieces and not fit for replantation. These stumps are treated with further bone shortening and closure, amputations through the base of proximal phalanx of index finger is treated with ray amputation of the 2nd metacarpal base.

Long term outcome of a grade 2 injury



Thumb CMC joint dislocations

This typical injury occurring in cracker burst, in due the fact that the thumb web gives least resistance for the blast wave to pass through in this process thumb CMC joint also injured. When the injury is severe it produces

amputation.

Picture showing dislocation of thumb CMC joint

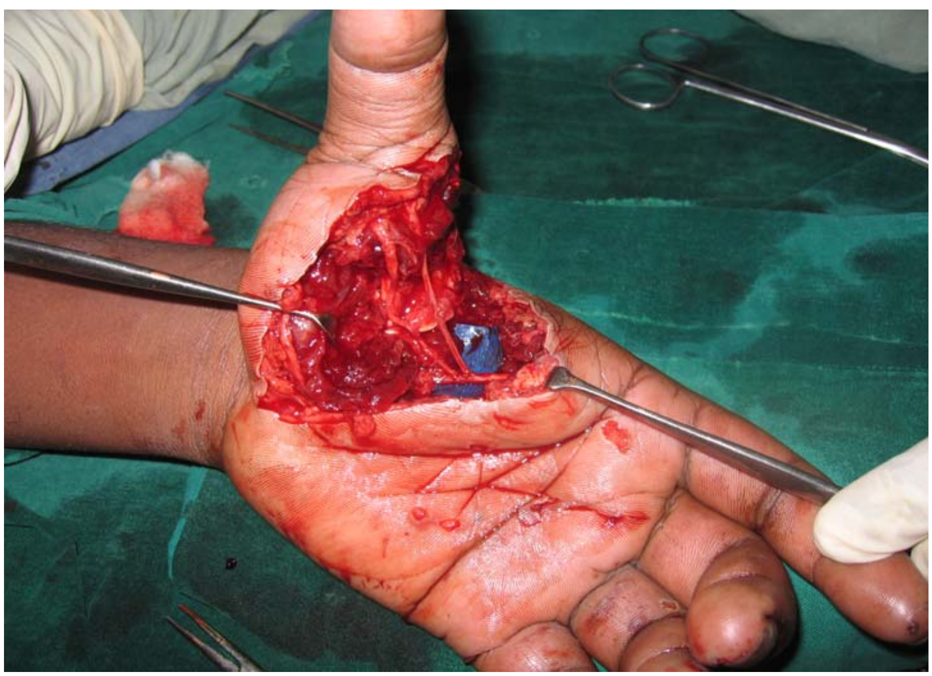
Dislocations require reduction and fixation with oblique ‘k’ wire passed disto-proximally, with the thumb in palmar abduction and opposition position.

When the dislocation is associated with fracture of the 1st metacarpal, it requires fixation of the metacarpal with a longitudinal ‘k’ wire, the same wire can be advanced across the CMC joint to fix the dislocation.

NERVE INJURIES

Median nerve branches to the thumb are most commonly injured one, they are found avulsed from the proximal median nerve from the level of carpal tunnel level. So they cannot be put back in to parent nerve directly. We usually repair them in end to side manner to the common digital nerve of index or middle finger. It gives good recovery of protective sensation by the end of six months. Other digital nerve injuries were treated by direct repair when the skin cover is adequate, otherwise secondary repair done after establishment of good skin cover.

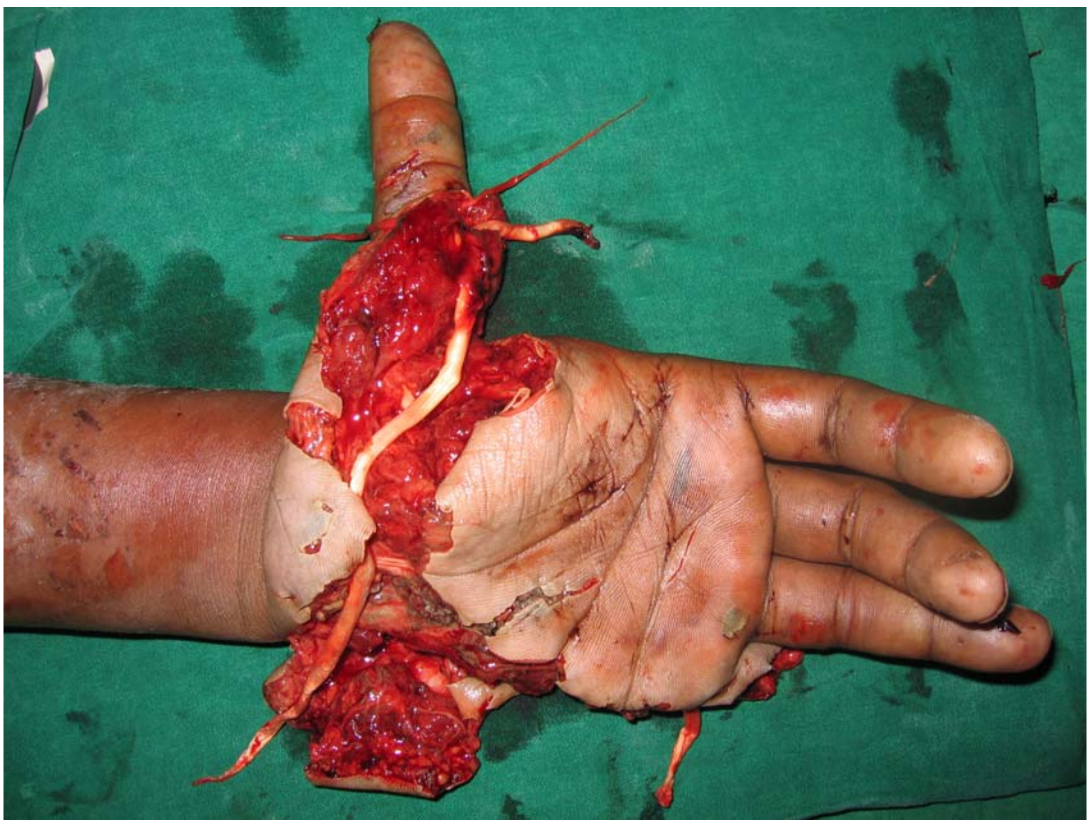
Picture showing the opened out CMC joint of thumb



Picture showing end to side digital nerve repair

TENDON INJURIES

Avulsion injury of flexor pollicis longus tendon from the muscle belly is common in severe injuries. Crushing of the FDP and FDS tendons of other fingers in the zone 1 and zone 2 level, primary tendon repair is under taken only when the skin cover is adequate, otherwise they were treated with trimming of the crushed edges and secondary reconstruction with tendon transfers.



Picture showing the avulsion of FPL tendon. And amputation of little finger

TREATMENT OF GRADE 4 INJURIES

A CASE OF BILATERAL GRADE 4 INJURY

Total thumb amputations;

These amputated thumbs are crushed and avulsed and generally not fit for replantation. They show multiple level skin and deeper tissue injuries, arteries are contussed & show intimal damage in examination under magnification.

Amputations occur commonly through the CMC joint and produce skin loss. All the total amputations were treated with debridement and tubed groin flap cover, groin flaps are divided and inset given 18 days later.

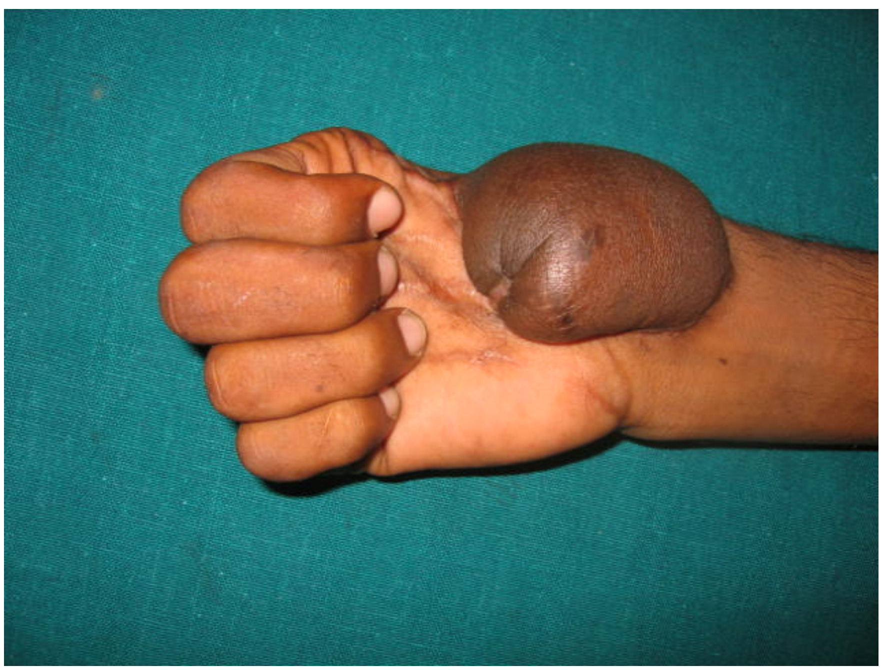
Pollicisation of the index finger done in one patient in our series, useful function has returned in that hand.

Amputations of fingers proximal to the MCP joint

These are associated with skin loss over the palm or dorsum or both.

After thorough debridement skin cover is given in the form of groin flaps, mobilization of the remaining fingers.

Recovery of useful function depends on the severity of original injury.



grade 4 injury 1 Long term result following grade 4 injury and groin flap cover

Carpal and forearm bone fractures

Two of our patients who had distal radius fracture and one had a scaphoid fracture, the displacement of the fragments were not much and they were treated conservatively with moulding and pop slab.

CONCLUSIONS

The grading system proposed in this study is useful in planning the treatment and predicting the prognosis. The outcome of the hand injury is depends upon the severity of the initial injury.

We are comfortable with the Groin flap for providing sufficient skin cover of the hand following the cracker burst injuries.

Nerve injuries are severely detrimental to the final outcome and end to side nerve repair offers possible solution the problem.

Thumb is the worst affected part of the hand following the cracker burst injury and it’s reconstruction remains a challenge for the surgeon.

The continuous availability of crackers through out the year in the markets is one of the reason for more number of injuries.

Social customs of bursting crackers during the temple festivals and funerals provide the opportunity for the accidents to occur.

Availability of high intensity fire crackers and crudely produced country made crackers used in the villages are reasons for the very severe injuries.

The unsafely practice of bursting crackers in the hand is the major culprit for the entire problem.

Cracker burst injury to hand can lead to major hypovolemic shock, as shown in study 10% of the patients required blood transfusions during resuscitation

Prevention of these injuries can be done by formulation and strict enforcement for legislature to follow the safety precautions and banning the production of high intensity fire crackers.

Thumb and thumb web injury is one of the most important factor in predicting the prognosis.

BIBLIOGRAPHY

1. Crompton R, Gall D. Georgi Markov -- death in a pellet. Med Leg J 1980;48:51-62.

2. Karmy-Jones R, Kissinger D, Golocovsky M, Jordan MH, Champion HR. Bomb-related injuries. Mil Med 1994;159:536-539.

3. Federal Bureau of Investigation. 1999 Bombing incidents. Washington, D.C.: Department of Justice, 2003. (FBI Bomb Data Center publication no. 0367.)

4. Champion HR, Oschner MG, Bellamy R. Surgery of victims of conflict. In: Moore EE, Mattox KL, Feliciano DV, eds. Trauma. 5th ed. New York: McGraw-Hill, 2004:1161-93.

5. Cullis IG. Blast waves and how they interact with structures. J R Army Med Corps 2001;147:16-26.

6. Arnold JL, Halperin P, Tsai MC, Smithline H. Mass casualty terrorist bombings: a comparison of outcomes by bombing type. Ann Emerg Med 2004;43:263-273.

7. Gans L, Kennedy T. Management of unique clinical entities in disaster medicine. Emerg Med Clin North Am 1996;14:301-326.

8. Guy RJ, Glover MA, Cripps NP. The pathophysiology of primary blast injury and its implications for treatment. Part I: the thorax. J R Nav Med Serv 1998;84:79-86.

9. Jensen JH, Bonding P. Experimental pressure induced rupture of the tympanic membrane in man. Acta Otolaryngol (Stockh) 1993;113:62-67.

10. Katz E, Ofek B, Adler J, Abramowitz HB, Krausz MM. Primary blast injury after a bomb explosion in a civilian bus. Ann Surg 1989;209:484-488.

11. de Candole CA. Blast injury. Can Med Assoc J 1967;96:207-214.

12. Coppel DL. Blast injuries of the lungs. Br J Surg 1976;63:735-737.

13. Mellor SG, Cooper GJ. Analysis of 828 servicemen killed or injured by explosion in Northern Ireland 1970-84: The Hostile Action Casualty System. Br J Surg 1989;76:1006-1010.

14. Irwin RJ, Lerner MR, Bealer JF, Mantor PC, Brackett DJ, Tuggle DW. Shock after blast wave injury is caused by a vagally mediated reflex. J Trauma 1999;47:105-110.

15. Guzzi LM, Argyros G. The management of blast injury. Eur J Emerg Med 1996;3:252-255.

16. Yang Z, Wang Z, Tang C, Ying Y. Biological effects of weak blast waves and safety limits for internal organ injury in the human body. J Trauma 1996;40:Suppl 3:S81-S84.

17. Brumback RJ. Traumatic rupture of the superior gluteal artery, without fracture of the pelvis, causing compartment syndrome of the buttock: a case report. J Bone Joint Surg Am 1990;72:134-137.

18. PF. Abdominal compartment syndrome as a consequence of rectus sheath hematoma. Am Surg 2003;69:975-977.

19. Vassalos A, Rana B, Patterson PRN, Grigoris P. Compartment syndrome -- current trends in Scottish practice. Scott Med J 2003;48:82-84.

20. Halpern P, Tsai MC, Arnold JL, Stok E, Ersoy G. Mass-casualty, terrorist bombings: implications for emergency department and hospital emergency response. Prehospital Disaster Med 2003;18:235-241.

21. Leibovici D, Gofrit ON, Stein M, et al. Blast injuries: bus versus open-air bombings -- a comparative study of injuries in survivors of open-air versus confined-space explosions. J Trauma 1996;41:1030-1035.

22. Leppaniemi A, Soltero R, Burris D, et al. Fluid resuscitation in a model of uncontrolled hemorrhage: too much too early, or too little too late? J Surg Res 1996;63:413-418.

23. Burris DG, Rhee P, Kaufmann CR, et al. Controlled resuscitation for uncontrolled hemorrhagic shock. J Trauma 1999;46:216-223.

24. Odhiambo WA, Guthua SW, Macigo FG, Akama MK. Maxillofacial injuries caused by terrorist bomb attack in Nairobi, Kenya. Int J Oral Maxillofac Surg 2002;31:374-377.

25. Lavanoas E. Blast injuries. (Accessed March 7, 2005, at

26. Treatment of primary blast injury. In: Emergency war surgery NATO handbook. Washington, D.C.: Department of Defense. (Accessed March 10, 2005, at

27. Wightman JM, Gladish SL. Explosions and blast injuries: a primer for clinicians. Atlanta: Centers for Disease Control and Prevention. (Accessed March 7, 2005, at

PROFORMA

Name	:	
Age	:	
P.S. Number	:	
Sex	:	Male / Female
Address	:	
Telephone number	:	
Occupation	:	
Details of the accident	:	
Place	:	
Time and date	:	
Occasion	:	Temple festival/funeral/Diwali
Alcohol intoxication	:	
Nature of the fire cracker	:	Factory made/ country made
Any previous history	:	

Of hand injuries :

Of systemic illnesses : diabetes/hypertension

Time of arrival in the dept:

Interval between the

injury& arrival :

Referred by :

First aid or any treatment

taken before :

Examination

General ; Vital signs

Hands :

Inspection :

Palm :

Thumb web & other webs:

Dorsum :

Thumb :

Index

Middle :

Ring :

Little :

Wrist and forearm :

Associated injuries :

Vascular status :

Sensory system :

Movements :

Diagnosis :

Diagrams

Investigations

RADIOLOGY :

X ray hand : 1) AP view

2) LATERAL view

X ray fore arm : 1) AP view

2) LATERAL view

Hand held Doppler study :

Routine blood investigations :

Informed consent for the surgery

Anesthesia : Axillary block

Digital block

Local infiltration anesthesia

Supraclavicular block

General anesthesia

For blocks a mixture of 2% lignocaine and 0.5% bupivacaine with adrenaline was used, except for the digital block where adrenaline was not used. General anesthesia was usually supplemented with Axillary blocks

Surgeon name :

Assistant name :

Scrub nurse name :

Duration of the procedure :

PROCEDURE DONE :

Skin cover :

Muscle repair :

Bone fixation :

Tendon repair :

Nerve repair :

Amputations

Inpatient / outpatient

Immediate post op Complications

Wound infection

Bleeding

Dehiscence

For inpatients :

Antibiotics used :

Duration of antibiotic use :

Date of discharge :

Condition on discharge :

Additional procedures done :

Physical therapy :

Duration :

Secondary procedures :

1)

2)

Range of movements :

Active :

Passive :

Sensory recovery :

Follow up :

Patient satisfaction :

(subjective assessment)

Satisfied

Not satisfied

Return to original work : Yes / no

Time interval between injury & return to work:

Objective assessment :

Remarks :

Duration of follow up :